Process Control: Temperature

Catalogue Number	77-3041-0002
Category	Process Control
Duration	15 Hours

Activity 1: Introduction to Process Control

- What is Process Control?
- What is a Control Mechanism?
- What is a Controller?
- Manual and Automatic Temperature Control Systems
- The Need for Controlling Systems

Activity 2: Introduction to ProcessMotion Simulation Software

- ProcessMotion Software
- ProcessMotion Panel
- Simulation Software
- Manipulating the ProcessMotion Panel Display
- Task: Running ProcessMotion and Opening Multiple Displays
- Review of Process Control
- Task: Running an Experiment
- Output Analysis
- Task: Analyzing the Output Graph
- Experimenting With an Ineffective Controller
- Task: Experimenting With an Ineffective Controller
- Interpreting the Output Graph
- Experimenting With an Effective Controller
- Task: Experimenting With an Effective Controller
- Interpreting the Output Graph

Activity 3: Block Diagrams and Gain

- Systems and Control Systems
- Sample Control Systems
- Block Diagrams
- Open Loop Control Systems and Gain
- Testing a Control System
- Task: Testing a Control System
- Testing Another Control System

Activity 4: Calculating Process Gain

- Review of Gain
- ProcessMotion Panel Control System
- Task: Constructing the Block Diagram of the System
- Defining Process Gain of the ProcessMotion System
- Analysis of the Tank Gain Equation
- Task: Calculating the Process Gain Analytically
- Calculating the Process Gain Experimentally
- Task: Calculating the Process Gain Experimentally
- Task: Recording the Data
- Task: Adjusting the Area of the Tank
- Task: Recording the Data
- Task: Calculating the Process Gain
- Conclusions

Activity 5: Heating Element Control

- Introduction to the Heating Element
- Controlling the Heating Element Using Voltage Control
- Pulse Width Modulation

Activity 6: First Order Systems

- Steady State Response
- Dynamic Response
- The Time Constant
- First Order Systems
- First Order System Laplace Transforms
- Step Inputs
- First Order System Response to a Step Input
- Notes on the Time Constant
- Task: Constructing a Graph of System Response to a Step Input
- Task: Interpreting a System Response Graph

Activity 7: The Temperature System Time Constant

- Review of the Time Constant
- The System Order of the Temperature System
- Deriving K and Tau for the Temperature System
- Analysis of the Steady Response of the Temperature System
- Analysis of the Dynamic Response of the Temperature System
- Applying a Step Input
- Determining the Dynamic Response of a First Order System
- Task: Measuring the Time Constant of the Temperature System Experimentally
- Task: Recording the Data
- Determining the Time Constant of a First Order Temperature System Analytically
- Task: Calculating the Time Constant Analytically

Activity 8: Controlling the Temperature System Using Open Loop Control

- Categorizing Control Systems
- Closed Loop Control
- Open Loop Control
- Controlling the Temperature System Using Open Loop Control
- Task: Using Open Loop Control to Control the Temperature of Water in the Tank
- Task: Recording the Data
- Task: Controlling the Temperature System With a Larger Tank Surface Area
- Task: Recording the Data
- Experiment Conclusions

Activity 9: Introduction to On-Off Control

- Open and Closed Loop Control Systems
- Closed Loop Control Systems
- On-Off Control Algorithm
- Task: Analyzing a Control System
- Applying On-Off Control
- On-Off Control Using Dead Band
- Tolerance

Activity 10: On-Off Control - Tasks

- On-Off Control
- Step Inputs
- Task: Step Inputs
- Task: Calculating General System Information
- System Behavior
- Task: Calculating the System Output Over Time
- The Descent of the System Response
- Task: Plotting the System Descent
- Investigating the Effects of Changing the Dead Band
- Task: Investigating the Effects of Changing the Dead Band

Activity 11: Controlling the Temperature System Using On-Off Control

- Review of Open Loop Control of the Temperature System
- On-Off Control of the Temperature System
- Task: Controlling the Temperature System Using On-Off Control
- Analysis of the System Output
- Task: Analysis of the Output Graph
- Task: Completing the Experiment
- Analysis of the Experiment Results

Activity 12: Proportional Control

- Proportional Control Algorithm
- Saturation
- Proportional Band
- Steady State System Characteristics Under Proportional Control
- Dynamic System Characteristics Under Proportional Control

Activity 13: First Order Systems Under Proportional Control

- Review of Proportional Control
- System Response to a Step Input
- Task: Calculating Time Values
- Task: Calculating the System Output for Kc = 0.5
- Task: Calculating the System Output for Kc = 1
- Task: Calculating the System Output for Kc = 2
- Task: Calculating the System Output for Kc = 4
- Task: Calculating the System Output for Kc = 10

Activity 14: Controlling the Temperature System Using Proportional Control

- Review of On-Off Control of the Temperature System
- Proportional Control of the Temperature System
- Task: Controlling the Temperature System Using Proportional Control
- Task: Recording the Experiment Results
- Task: Completing the Table
- Results and Conclusions

Activity 15: Proportional Integral Control

- First Order Systems Under Proportional Control
- Higher Order Systems Under Proportional Control
- Integral Control
- Proportional Integral Control
- Task: Constructing a Graph of the Output of a PI Controller
- How Integral Control Eliminates Offset
- Disadvantages of PI Control
- Applying Laplace Transform to PI Control

Activity 16: Controlling the Temperature system Using Proportional Integral Control

- Review of Proportional Control
- Controlling The Temperature System Using PI Control
- Task: Controlling the Temperature System with PI Controller
- Task: Recording the Data
- Task: Completing the Experiments
- Results and Conclusions

Activity 17: PID Control

- Review of Proportional Control
- Review of Proportional Integral Control
- Derivative Control
- Advantages of Applying a Derivative Action to a PI Controller
- Proportional Integral Derivative Control
- Demonstrating PID Control
- Task: Investigating the Effect of Changing PID Parameters
- Task: The Effect of Changing the Value of Kc
- Task: The Effect of Changing the Value of Ti
- Task: The Effect of Changing the Value of Td

Activity 18: Controlling the Temperature System Using Proportional Integral Derivative Control

- Review of P and PI Control
- Control of Higher Order Systems
- Review of PID Control
- Task: Controlling the ProcessMotion Temperature System with a PID Controller
- Task: Adjusting the Value of Td
- Results and Conclusions
- Task: Investigating the Effect of PID Control on a Higher Order System
- Task: Adjusting the Value of Kc When Using P Control
- Task: Adjusting the Value of Ti When Using PI Control
- Task: Adjusting the Value of Td When Using PID Control

Activity 19: Controller Selection and Design

- Designing a Control System
- Stage 1: Selecting an Appropriate Control Algorithm
- Stage 2: Determining the Correct Parameters
- Stage 3: Fine Tuning
- Setting the Parameters for a PID Control System
- Task: Determining the Critical Gain Value
- Task: Determining the Cycle Time
- Task: Fine Tuning the PID Controller

Activity 20: Designing Controllers for the Temperature System

- Review of the Controller Design Process
- Control Algorithms
- Designing a Controller for the Temperature System: 1
- Task: Experimenting with the Controller
- Task: Examining the Controller Performance
- Task: Evaluating the Controller Performance
- Designing a Controller for the Temperature System: 2
- Task: Testing the Controller
- Task: Examining the Controller Performance
- Task: Evaluating the Controller Performance
- Experiment Results
- Designing a Controller for the Temperature System: 3
- Task: Testing the Controller
- Task: Examining the Controller Performance
- Experiment Results

Post-test